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RECOMMENDATIONS

FOR AN

IMPROVED AND EXPANDED

FLOOD FORECASTING SYSTEM

FOR THE

SUSQUEHANNA RIVER BASIN

SUSQUEHANNA RIVER BASIN COMMISSION

SEPTEMBER 12, 1973

THESE RECOMMENDATIONS WERE UNANIMOUSLY ADOPTED BY THE SUSQUEHANNA RIVER BASIN COMMISSION ON SEPTEMBER 12, 1973.

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INTRODUCTION

The Flood Forecasting and Warning System within the Susquehanna River Basin, operated by the National Weather Service, was placed under a tremendous strain during the height of Tropical Storm Agnes in 1972.

The National Advisory Committee on Oceans and Atmosphere studying the performance of the system during Agnes reports that, "Taxed to the limits of its capacity, the system appears to have barely coped with the behavior of a most exceptional storm. The cost to establish a failsafe warning system scaled to disasters of an exceptional intensity would be unacceptable". This comment points up the fact that the National Weather Service system is designed to handle routine operations and ordinary emergencies.

In Pennsylvania, the Weather Wire did not have sufficient subscribers to make it an adequate warning medium. In New York State, where the Weather Wire is not installed, broadcasters monitored other stations and maintained some contact by telephone.

As the flood waters rose to record levels, 22 river gaging stations out of 60 on the Susquehanna River became inoperative or were destroyed, and communications systems began deteriorating. Parts of the Federal-State Radio River and Rainfall Reporting Network also became inoperative.

Power failures were prevalent throughout the basin, affecting the timely collection of rainfall and river information as well as the preparation and dissemination of flood forecasts. Failure of power at the Harrisburg Weather Service Office was most critical. The Weather Service staff had to perform forecast operations manually under lantern light. When the telephone and teletypewriter system also failed, time-consuming emergency methods were employed to collect substation reports and disseminate forecasts. Although not able to receive incoming calls, the staff did make countless outgoing calls to obtain additional data regarding rainfall and stream gage readings.

The Agnes flood dramatized the weaknesses of the data collection network. In the case of river gages, the cooperative observer usually lives or works near the river. Not only does he have telephone lines vulnerable to flooding, but in serious floods he understandably must be more concerned with saving his family and property than he is with reading the river gage which may become inaccessible during a flood period. Rainfall observers, in many cases, had difficulty in reporting due to telephone failure.

Another problem uncovered in the investigations following the Agnes disaster was lack of public understanding and reaction to forecasts and warnings issued by the National Weather Service.

The reaction to these warnings and reports varied widely in the Susquehanna Basin and also throughout the Eastern United States where Agnes dealt its most devastating blows Response ranged from prompt action to warn others and evacuate hazard areas to virtual dismissal of the warnings. Factors which contributed to the varied response were the urgency reflected by the mass news media, past experiences, wording of the releases, and the length of lead time before flooding was projected

The public response also was tempered by confusion and misunderstanding. Few people knew the difference between a flood watch and a flood warning, and between flash floods and river floods. Confusion between the two latter terms is thought to have caused poor public response to river flood warnings issued after flash flood waters began to recede. Another problem unveiled was the inability of local action agencies and news media to equate forecast stream stages with the potential flood damage areas. This lack of information also was a factor that delayed public response.

THE EXISTING SYSTEM

The Flood Forecasting and Warning System for the Susquehanna River Basin is part of a similar network across the country. The National Weather Service Office in Harrisburg serves as the River Forecast Center (RFC) for the entire Susquehanna River Basin as well as the River District Office (RDO) for the Maryland and Pennsylvania parts of the basin. The New York section of the basin is served by an RDO in Binghamton, New York.

The RDOs maintain a network of observing stations that report river stages, precipitation amounts and other parameters as required. These reports are collected and relayed to the RFC at Harrisburg. Forecasts are prepared at the centers, then transmitted to the river districts for dissemination In the Susquehanna River Basin there are a total of 76 river and rainfall stations monitored by the Harrisburg and Binghamton River District Offices. Issuance of river forecasts and flood warnings to the general public, specialized users and media such as newspapers, radio and TV stations is one of the RDOs' principal functions. When conditions warrant, RDOs may issue preliminary warnings before detailed forecasts have been prepared by the RFC.

DEVELOPMENT OF A PLAN OF EXPANSION & IMPROVEMENT

In the wake of the Agnes flood and the obvious limitations of the present system, the Commission coordinated an effort to have all interested State and Federal agencies meet for the purposes of discussing the problems and to develop a plan to expand and improve the current system.

Although the plan as presented here is not a failsafe one its primary objectives are to expand the existing system sufficiently to improve the forecasting capabilities, to provide forecasts for more areas and to increase the warning time to residents and other occupants of flood prone areas

The Commission plan provides a two-pronged approach The first part deals with the expansion and improvement of the forecasting system in terms of added reporting stations and equipment for the Susquehanna River and its major tributaries The second part deals with establishment of a Self-Help Program of Flood Warning and Forecasting for Small Watersheds.

PART I

EXPANSION AND IMPROVEMENT OF PRESENT SYSTEM

The Commission plan recommends the placement of thirteen new staff gages; six in New York; five in Pennsylvania and two in Maryland with forecasts to be issued at the following communities which do not now receive stage and timing forecasts. The communities are Oneonta, Unadilla, Sidney, Owego, Waverly, Gang Mills, Athens, Berwick, Milton, Selinsgrove, Duncannon, Port Deposit and Havre De Grace. Staff gages are boards painted with graduations in feet and tenths used for measuring river stages. Also recommended is the placement of one new recording gage with a telemeter to be placed at Tunkhannock, Pennsylvania in Lycoming County. This automatic reporting gage would measure stream stage as the level of the stream rises and falls. The telemetering device would automatically transmit, via radio waves or ground lines, the information recorded.

A list showing the location by community, type of equipment, estimated basic installation cost of rain and staff gages can be found in Appendix I.

The placement of thirteen new staff gages will increase the accuracy of future forecasts and provide additional valuable lead time needed for evacuation and other emergency measures by local communities.

The installation of three additional recording gages with telemeters is recommended at Lock Haven, Pennsylvania, Waterville, Pennsylvania and Lewistown, Pennsylvania to supplement existing equipment at these key data collection and forecasting locations.

The Commission also recommends the placement of twenty-one back-up staff gages in the Pennsylvania sector of the basin. These gages will be regular staff gages placed in higher, more pro-

tected areas to be used in case the main gage is washed away or becomes inaccessible as occurred during the June 1972 flood. A list showing the location by community and estimated installation cost of these twenty-one back-up gages can be found in Appendix II.

The third recommendation calls for the placement of eighteen automatic rain gages with telemetering devices, five of which are to be located in New York and thirteen in Pennsylvania. These gages automatically record rainfall by weighing amounts of precipitation and transferring the weight measured onto a graph or punch tape where it is interpreted as precipitation in inches. A listing in Appendix III shows the location by community and approximate installation costs per site.

Appendix IV shows the estimated funds needed over the next three fiscal years to supply the new equipment the Commission recommends for the improvement and expansion of the system. Appendix V shows estimated costs for projects in each state.

It is important to note here that the figures presented in the Appendices illustrate average installation costs and these may vary from site to site. It will also be the responsibility of the National Weather Service to recommend priorities for the program.

PART II

SELF-HELP PROGRAM OF FLOOD FORECASTING & WARNING

The second part of the Commission's overall program calls for establishment of a Self-Help Flood Forecasting and Warning Program for small watersheds in the basin.

The need for such a program in smaller watersheds arises from the fact that these areas often receive heavy local rain causing flash flooding. These flash floods and local rains may cause only minor changes in the main river or major tributaries. The watersheds and the communities within their subbasins need a system whereby they can locally develop warnings and forecasts of flash floods. These smaller areas in times of flash flooding or major disasters like Agnes may lose communications with surrounding areas very quickly. Without some means of providing warnings and forecasts for their streams the developments in flood prone areas could very easily suffer loss of lives and extensive damage that otherwise might be averted or reduced.

The establishment of such a program in upstream watersheds would also supplement the overall basin data collection system in

providing additional information and thereby increase lead time for warning and forecasting the arrival of flood waters at potential damage areas downstream.

The Self-Help Program provides for development of flood warning services through local flood warning committees. The overall program includes assistance in setting up coordination procedures, development of technical information such as rainfall - runoff relationships and the installation of rain and crest gages.

Initially the following watersheds are suggested:

WATERSHED AND COMMUNITIES	TOTAL DRAINAGE AREA
Chenango River: Sherburne, Norwich, Oxford, Greene	727 Sq.Mi.
Tioughnioga River: Truxton, Cortland, McGraw, Marathon, Whitney Point	458 Sq.Mi.
Owego Creek: Candor, Newark Valley, Owego	341 Sq.Mi.
Cowanesque River: Westfield, Knoxville, Elkland, Lawrenceville	301 Sq.Mi.
Canisteo River: Almond, Hornell, Canisteo, Addison	554 Sq.Mi.
Cohocton River: Avoca, Bath, Campbell, Painted Post	607 Sq.Mi.
Fishing Creek: Benton, Orangeville, Bloomsburg	386 Sq.Mi.
Moshannon Creek: Osceola Mills, Philipsburg	275 Sq.Mi.
Bald Eagle Creek: Bellefonte, Milesburg	350 Sq.Mi.
Conodoguinet Creek: Roxbury, Newville, Carlisle, Hampden Township, Camp Hill	508 Sq.Mi.
Yellow Breeches Creek: Mt. Holly Springs, Williams Grove, Upper Allen Township, Fairview Township, New Cumberland Area	220 Sq.Mi.
Swatara Creek: Pine Grove, Jonestown, Lebanon, Annville, Union Deposit, Hummelstown, Middletown	567 Sq.Mi.
Codorus Creek: Spring Grove, Glen Rock, Seven Valleys, York	222 Sq.Mi.

A chart showing the estimated costs of the Self-Help Program including services and equipment needed can be found in Appendix VI.

Appendix VII shows the minimum estimated funds needed over the next three fiscal years to operate the program.

Appendix VIII illustrates the estimated costs by States for establishing small watersheds services for the areas listed in Appendix VII.

The total cost of implementing overall program is estimated at $268,500.

ADDITIONAL NEEDS

Once additional gages are placed and self-help programs are established to collect data,the important problem still remains of transmitting the data to the Harrisburg RFC for interpretation, calculation and returning it to individual areas for dissemination.

An improved communication system must be made available if data is to flow freely and uninterpreted in order that warnings may be issued in time to be meaningful. The overall topic of communication between the central flood forecasting center in Harrisburg and the data collection stations and the public will be the subject of a separate study and report.

Emergency Action Plans must also be developed on a local level to provide for evacuation in times of flooding and to provide other emergency services on a local basis.

The proposal as presented here by the Commission is intended to offer initial recommendations on improvement of the data collection system on the Susquehanna River and its major tributaries and establishment of a small watershed self-help program. A vital need remains for improved communications as mentioned earlier with a possible back-up system by using the ERTS satellite currently being experimented with in the basin under a cooperative agreement between the USGS and the Commission. The satellite is currently monitoring river stages at three locations in the basin and automatically transmitting readings via ERTS to the Harrisburg RFC. Observers feel the monitoring stations would perform under adverse conditions because they are battery operated and located above flood levels. The system's independence of electric power or phone lines for transmission of data makes it noteworthy when considering improved communications. The use of this satellite could be a vital link in forming the best possible system of warning and forecasting in the Susquehanna River Basin.

APPENDIX I

The location by community, type of equipment and estimated basic installation costs for installation of rain and staff gages are as follows:

LOCATION	COUNTY	RIVER	DRAINAGE AREA	EQUIPMENT REQUIRED	COST INSTALLATION
New York					
Oneonta	Otsego	Susquehanna	686	Staff Gage	$ 1,000
Sidney	Otsego	Susquehanna	1,587	Staff Gage	1,000
Owego	Tioga	Susquehanna	4,243	Staff Gage	1,000
Gang Mills	Steuben	Tioga	1,386	Staff Gage	1,000
Pennsylvania					
Athens	Bradford	Chemung	2,596	Staff Gage	1,500
Tunkhannock	Wyoming	Susquehanna	9,306	Recording Gage With Telemeter	25,000
Berwick	Columbia	Susquehanna	10,485	Staff Gage	1,500
Lock Haven	Clinton	West Branch	4,117	Recording Gage With Telemeter	25,000
Waterville	Lycoming	Pine Creek	944	Recording Gage With Telemeter	20,000
Milton	Northumberland	West Branch	6,688	Staff Gage	1,500
Selinsgrove	Snyder	Susquehanna	18,470	Staff Gage	1,500
Lewistown	Mifflin	Juniata	2,714	Recording Gage With Telemeter	25,000
Duncannon	Perry	Susquehanna	23,146	Staff Gage	1,500
Maryland					
Port Deposit	Cecil	Susquehanna	27,500	Staff Gage	1,500
Havre De Grace	Harford	Susquehanna	27,500	Staff Gage	1,500
				Total	$109,500

APPENDIX II

The following list includes the location of staff and backup gages on high ground keyed to recording or streamside staff gages

LOCATION AND STREAM	COUNTY	RANGE	TOTAL LENGTH	ESTIMATED COST
Towanda, Susquehanna	Bradford	16-39	21	$ 1,000
Dixon, Tunkhannock Creek	Wyoming	5-14	9	1,000
Archbald, Lackawanna	Lackawanna	5-16	12	1,000
Wilkes-Barre, Susquehanna	Luzerne	15-46	31	1,000
Danville, Susquehanna	Montour	20-38	18	1,000
Karthaus, West Branch	Clearfield	10-24	12	1,000
Sinnemahoning, Sinnemahoning Creek	Cameron	8-27	19	1,000
Renovo, West Branch	Clinton	15-35	20	1,000
Lock Haven, West Branch	Clinton	10-27	27	1,000
Beech Creek Station, Bald Eagle	Clinton	8-20	12	1,000
Jersey Shore, West Branch	Lycoming	18-43	25	1,000
Williamsport, West Branch	Lycoming	10-35	25	1,000
Milton, West Branch	Northumberland	0-40	40	1,000
Lewisburg, West Branch	Union	10-39	29	1,000
Sunbury, Susquehanna	Northumberland	16-41	25	1,000
Williamsburg, Frankstown Branch	Blair	6-24	18	1,000
Huntingdon	Huntingdon	12-17	25	1,000
Mapleton Depot	Huntingdon	10-43	33	1,000
Lewistown	Mifflin	15-47	32	1,000
Newport	Perry	10-37	27	1,000
Harrisburg, Susquehanna	Dauphin	10-38	28	1,000
			Total	$21,000

APPENDIX III

The following is a listing of automatic raingages

New York

LOCATION	COUNTY	SUBBASIN	ESTIMATED INSTALLATION COST
Hartwick	Otsego	Eastern	$ 2,000
Worchester	Otsego	Eastern	2,000
McGraw	Cortland	Eastern	2,000
Candor	Tioga	Eastern	2,000
Cayuta	Chemung	Chemung	2,000

Pennsylvania

Westfield	Tioga	Chemung	2,000
Hop Bottom	Susquehanna	North Branch	2,000
Benton	Columbia	North Branch	2,000
Cedar Run	Lycoming	West Branch	2,000
Raymond B. Winter State Park	Union	West Branch	2,000
Hublersburg	Centre	West Branch	2,000
Reeds Gap	Juniata	Juniata	2,000
Roxbury	Franklin	Lower	2,000
Indiantown Gap	Lebanon	Lower	2,000
Hunters Run	Cumberland	Lower	2,000
Siddonsburg	York	Lower	2,000
Ephrata	Lancaster	Lower	2,000
Glen Rock	York	Lower	2,000
		Raingages Total	$36,000

APPENDIX IV

The following chart shows the estimated funds for placement of new, and/or back-up staff gages. Some communities will be receiving new gages to replace ones washed away during Agnes.

ITEM	ACTING AGENCY	FY-74	FY-75	FY-76
	New River Gages			
New York				
Oneonta, Sidney, Owego, Gang Mills	USGS New York	$ 4,000	--	--
Pennsylvania				
Athens, Tunkhannock, Berwick, Milton, Lock Haven, Selinsgrove, Duncannon, Waterville, Lewistown	USGS Pennsylvania	32,000	25,000	45,000
Maryland				
Port Deposit, Havre De Grace	USGS Maryland	3,000	--	--
	Backup Staff Gages			
Pennsylvania				
Towanda, Dixon, Archbald, Wilkes-Barre, Danville, Karthaus, Sinnemahoning, Renovo, Lock Haven, Beech Creek, Jersey Shore, Williamsport, Milton, Lewistown, Sunbury, Williamsburg, Huntingdon, Mapleton, Lewisburg, Newport, Harrisburg	USGS Pennsylvania	14,000	7,000	--

ITEM	ACTING AGENCY	FUNDS REQUIRED FY-74	FY-75	FY-76
New Telemeter Rain Gages				
New York				
Hartwick, Worchester, McGraw, Candor, Cayuta	NOAA	$10,000	--	--
Pennsylvania				
Westfield, Hop Bottom, Benton, Cedar Run, Raymond B. Winter State Park, Hublersburg, Reeds Gap, Roxbury, Indian-Town Gap, Hunters Run, Siddonsburg, Ephrata, Glen Rock	NOAA	10,000	--	--
			Total Cost	$166,500

APPENDIX V

Costs for projects in each State are estimated as follows:

ITEM	NEW YORK	PENNSYLVANIA	MARYLAND	BASIN TOTAL
Improved and Expanded Data Collection				
River Network	$ 4,000	$102,500	$ 3,000	$109,500
Backup Staff Gages	--	21,000	--	21,000
Rain Gages	10,000	26,000	--	36,000
	$14,000	$149,500	$ 3,000	$166,500

APPENDIX VI

The following chart shows the estimated costs of the Small Watershed Self-Help Program.

WATERSHED	SERVICES	EQUIPMENT	TOTAL
Chenango	$7,000	$1,200	$8,200
Tioughnioga	7,000	1,000	8,000
Owego	7,000	1,000	8,000
Cowanesque	7,000	1,200	8,200
Canisteo	7,000	1,200	8,200
Cohocton	7,000	1,200	8,200
Fishing Creek	7,000	1,200	8,200
Moshannon	7,000	1,000	8,000
Bald Eagle	7,000	1,000	8,000
Conodoguinet	6,000	1,500	7,500
Yellow Breeches	6,000	1,000	7,000
Swatara	6,000	1,500	7,500
Codorus	6,000	1,000	7,000
		Total	$102,000

APPENDIX VII

The following chart shows funds required to establish Self-Help Program.

ITEM	ACTING AGENCY	FUNDS REQUIRED FY-74	FY-75	FY-76
New York				
Small Watershed Assistance				
Canisteo, Owego, Cohocton, Tioughnioga, Chenango, Moshannon, Bald Eagle, Codorus, General Reconnaissance, etc.	SRBC	$17,500	$10,000	--
Technical Services				
Canisteo, Owego, Cohocton, Tioughnioga, Chenango, Moshannon, Bald Eagle, Codorus, General Reconnaissance, etc.	NOAA	--	17,500	10,000
Data Gathering Equipment				
Canisteo, Owego, Cohocton, Tioughnioga, Chenango, Moshannon, Bald Eagle, Codorus, General Reconnaissance, etc.	NOAA	--	5,600	3,000
Pennsylvania				
Small Watershed Assistance				
Yellow Breeches, Swatara, Conodoguinet, Fishing Creek, Cowanesque, General Reconnaissance, etc.	SRBC	16,000	--	--

ITEM	ACTING AGENCY	FUNDS REQUIRED		
		FY-74	FY-75	FY-76
Technical Services				
Yellow Breeches, Swatara, Conodoguinet, Fishing Creek, Cowanesque	NOAA	--	16,000	--
Data Gathering Equipment				
Yellow Breeches, Swatara, Conodoguinet, Fishing Creek, Cowanesque	NOAA	--	6,400	--
Total Funds by Fiscal Year		$33,500	$55,500	$13,000
		GRAND TOTAL		$102,000

APPENDIX VIII

Estimated costs by State for establishing small watershed services for those areas listed in Appendix VIII.

AGENCY	NEW YORK	PENNSYLVANIA	TOTALS
Establishing Local Program (SRBC)	$ 17,500	$26,000	$ 43,500
Federal Forecast Services (NOAA)	17,500	26,000	43,500
Federal Forecast Equipment (NOAA)	5,600	9,400	15,000
	$ 40,600	$61,400	$102,000

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